MRI EVALUATION OF THE LUMBAR SPINE LIGAMENTUM FLAVUM & ITS CONTRIBUTION TO DEGENERATIVE SPINAL STENOSIS

DR. TEH HAK LIAN

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ABSTRAK

Pengenalan: Stenosis tulang belakang lumbar merupakan satu masalah perubatan melibatkan penyempitan saluran tulang belakang menyebabkan himpitan korda spinal dan saraf pada paras tulang belakang lumbar. Punca stenosis tulang belakang termasuk: hipertrofi flavum ligamentum, herniasi cakera intervertebral dan hipertrofi sendi faset. Ligamentum flavum (LF) adalah struktur anatomi, bermula dari vertebra servikal ke 2 sehingga tulang belakang sakral pertama. Ia merangkumi lamina vertebra dan membentuk permukaan belakang saluran tulang belakang. Objektif kajian ini adalah untuk memahami sumbangan ligamentum flavum dalam patoanatomi stenosis degeneratif tulang belakang lumbar.

Metodologi: Ini adalah kajian keratan rentas retrospektif yang melibatkan MRI 50 pesakit muda tanpa stenosis tulang belakang dan 50 pesakit yang lebih tua dengan stenosis tulang belakang dari Januari 2010 hingga Disember 2016 di Hospital Universiti Sains Malaysia. Pesakit bukan stenosis/muda tidak mempunyai tanda dan gejala stenosis tulang belakang. Sementara itu, kumpulan pesakit stenosis yang lebih tua mempunyai tanda dan simptom stenosis tulang belakang dan telah menjalani pembedahan.

Hasil & perbincangan: Terdapat hubungan linear yang ketara antara ketebalan LF dengan umur di kalangan kumpulan bukan stenosis muda ($P < 0.05$) manakala dalam kumpulan stenosis tulang belakang yang lebih tua, umur tidak mempunyai hubungan yang signifikan dengan ketebalan LF. Ketebalan LF dalam kumpulan stenosis adalah lebih signifikan berbanding dengan kumpulan bukan stenosis ($P < 0.05$). Terdapat lebih banyak lanjutan ke atas daripada lanjutan ke bawah LF dalam kedua-dua kumpulan dan LF paling tebal terletak di kawasan sublaminar. Lokasi LF yang

paling tebal terletak 1/3 dari keseluruh lamina. Tidak ada hubungan yang signifikan antara ketebalan LF dengan jumlah cakera intervertebral yang herniated.

Kesimpulan: Keputusan patoanatomi yang diperolehi boleh membantu pakar bedah menjalankan pembedahan dekompresi dengan lebih berkesan dan selamat justeru membantu para pesakit pulih dari penyakit spinal stenosis.

ABSTRACT

Introduction: Lumbar spinal stenosis (LSS) is a medical condition in which the spinal canal narrows and compresses the spinal cord and nerves at the level of the lumbar vertebra. Causes of spinal stenosis include: hypertrophy of ligamentum flavum, herniated intervertebral disc and hypertrophy of facet joint. Ligamentum Flavum (LF) is an anatomical structure, extends from the 2^{nd} cervical vertebra through to the 1^{st} sacral vertebra. It spans the vertebral lamina and forms the dorsal surface of the spinal canal. The objective of this study is to understand the contribution of ligament flavum in the pathoanatomy of degenerative lumbar spinal stenosis.

Methodology : This is a retrospective cross sectional study involving MRI of 50 young patients without spinal stenosis and 50 older patients with spinal stenosis from Jan 2010 to Dec 2016 in Hospital University Sains Malaysia. The young non stenotic patients have no signs and symptoms of spinal stenosis. Meanwhile the older stenotic group of patients have signs and symptoms of spinal stenosis and were operated.

Results & discussion : There is a significant strong linear relationship between thickness of LF with age among the young non-stenotic group ($P < 0.05$) whereas in older spinal stenosis group, age has no significant relationship with thickness of LF . The thickness of LF in stenotic group is significantly thickened compared to non stenotic group ($P<0.05$). There were more cranial extension than caudal extension of LF in both groups and the thickest LF were situated at the sublaminar region. The location of thickest LF is situated at lower 1/3 from the inferior edge of lamina. There is no significant association between thickness of LF with the amount of herniated intervertebral disc but herniated disc mostly occurs in conjunction with thickened ligamentum flavum.

Conclusion : Thickening of LF is an age dependent process ,however this increment of thickening was not seen in spinal stenosis group. In LSS group L3/L4 level has the thickest LF and has the most cranial extension. For complete flavectomy/ decompression, at least 12mm of lamina from the inferior edge has to be removed .

Keywords : lumbar spinal stenosis , ligamentum flavum ,thickness, decompressive laminectomy.

Chapter 1

INTRODUCTION

INTRODUCTION :

Lumbar spinal stenosis (LSS) is a medical condition in which the spinal canal narrows and compresses the spinal cord and nerves at the level of the lumbar vertebra. LSS means the space available for nerve elements was reduced (Amundsen *et al.*, 1995). LSS is either developmental and/or acquired condition that results in the formation of a neural arch smaller than normal in diameter and result triangular rather than round (Epstein *et al.*, 1964). Causes of spinal stenosis includes: hypertrophy of ligamentum flavum, herniated intervertebral disc and hypertrophy of facet joint.

Plain x-rays of the lumbar spine may or may not show spinal stenosis. The definitive diagnosis is established by either computerized tomography (CT) scanning or magnetic resonance imaging (MRI). Identifying the presence of a narrowed canal makes the diagnosis of spinal stenosis. MRI and CT scan are able to detect the cardinal features of stenosis — reductions in the cross-sectional area of the central canal and neural foramina due to a combination of disk protrusion, redundancy and hypertrophy of the ligamentum flavum, and hypertrophy of facet joints, with accompanying osteophytes (Katz and Harris, 2008). Incomplete removal of ligamentum flavum during decompression surgery results in persistent symptoms in spinal stenosis patients.

Ligamentum flavum is an anatomical structure, which extends from the 2nd cervical vertebrae to the 1st sacral vertebra [1][2]. It spans the vertebral lamina & forms the dorsal surface of the spinal canal. It wraps around the medial aspect of the spinal articulations and is composed more of elastic than collagen fibers, hence its yellow color. Its elasticity diminishes with age, and there is a loss of the elastic fibers and a concomitant increase of collagen fibers. (Kosaka H, Sairyo K et al. (2007). This ligament consists of a superficial and a deep component. The superficial component is inserted into the superior and posterosuperior edges of the caudal lamina. The deep component is inserted at a variable distance into the anterosuperior surface of the caudal lamina.(Olszewski AD et al 1996).

Classical anatomical description of the LF was proposed by Naffzinger et al proposed that, LF attached to the inferior& anterior inferior surface of cephalad lamina and inserted into the superior & posterior surfaces of caudal lamina. Its thickening can be attributed to the development of lumbar spinal stenosis.

This study is aimed to provide details of ligamentum flavum thickness at the L2 to S1 Levels in understanding its contribution in spinal stenosis and adequate spinal decompression.

Chapter 2

OBJECTIVES OF THE STUDY

General objective:

To understand the contribution of ligament flavum in the pathoanatomy of degenerative lumbar spinal stenosis.

Specific objectives :

1. To compare the mean thickness of ligamentum flavum in lumbar spine in non-stenotic (20-40 years old) populations and patients with lumbar stenosis (50-80 years old).
2. To see the correlation between thickness of the LF with age of the patients in both groups.
3. To measure the amount of cranial & caudal extension of LF in both groups of patients.
4. To identify the exact location of maximum extension of LF in both groups of patients either (sublaminar/infralaminar).
5. To identify the ratio of LF encroachment (mm): lumbar disc herniation (mm) from mid sagittal MRI of lumbar spine in patient with spinal stenosis.
6. To identify location of the thickest LF calculated from the inferior lamina in relation to the entire length of the lamina (mm) in older spinal stenosis group

Chapter 3

MANUSCRIPT

3.1. TITLE: MRI evaluation of the lumbar spine ligamentum flavum & its contribution to spinal stenosis

Author: Dr. TEH HAK LIAN

Department of Orthopaedics,

School of Medical Sciences, Universiti Sains Malaysia,

16150 Kota Bahru, Kelantan

Corresponding Author:

Dr TEH HAK LIAN

Department of Orthopaedics, School of Medical Sciences, Universiti Sains Malaysia,

Kota Bharu, 16150 Kota Bahru, Kelantan, MALAYSIA

Email: drteh1984@yahoo.com ; Tel: +609-7676389; Fax: +609-7653370

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6. To identify the location of the thickest LF calculated from the inferior lamina in relation to the entire length of the lamina (mm) in spinal stenosis group.

Methodology

In this retrospective cross sectional study, 100 MRI of patients were enrolled from January 2010 till December 2016.

Sample size estimation

Sample size for this study was calculated based on objective 2 (association between thickness of the LF and age of the patients in spinal stenosis) using G*Power Software version 3.1.9.2 Faul et al. 2007 University Kiel, Germany. Based on sample size for bivariate correlation analysis, with type I error of 5% (two tailed), type II error of 20%, and the smallest correlation coefficient to be detected is 0.4, the sample size calculated was 46 per group. The total number of participants required for this study was 51 per group. Since this study involved two group, the total number of participants was 102 participants.

Sampling method

Records of patient's lumbo sacral MRI (Philip 3 Tesla Achieva MR Scanner, Netherlands) from January 2010 to December 2016 who fit the inclusion criteria will be extracted from the PACS radiology software system (GE Centricity PACS Universal Viewer Web Client Version 5) in HUSM. Sampling method – non probability

Research tool

Magnetic Resonance Imaging (MRI) machine (Philip 3 Tesla Achieva MR Scanner, Netherlands) The scanning and image acquisition were open bore diameter of 70 cm, maximum FOV of 55 cm, typical homogeneity at 55 x 55 x 50 cm < 5ppm and typical homogeneity at 50 x 50 x 45 cm < 1.8ppm. It was a helium save technology (zero boil-off) with cryogen boil-off rate 0.01/ hour with maximum scan matrix of 1024 (2048 optimal). Software (GE Centricity PACS Universal Viewer Web Client Version 5)

Computer (HP ZR22w with CPU Z400 workstation)

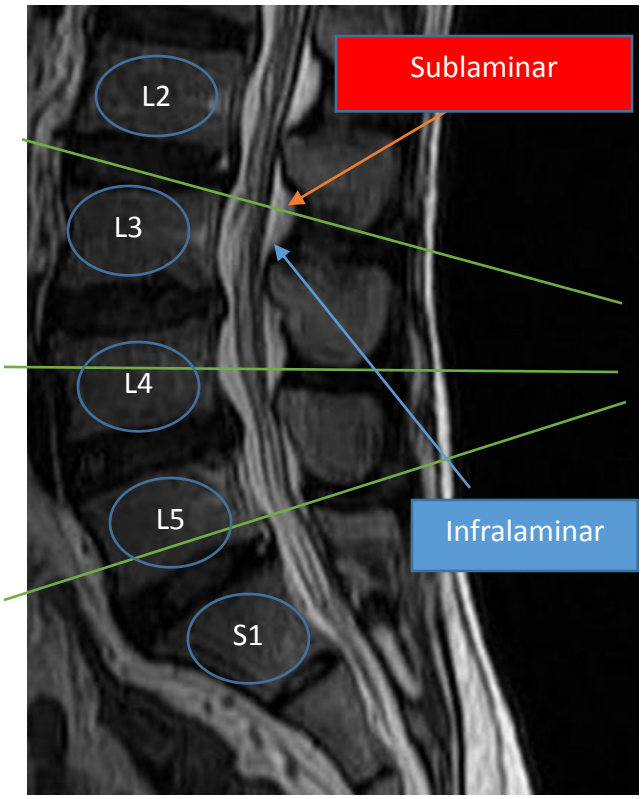
Data collection method

Axial & sagittal T2 weighted MRI images of lumbosacral were obtained from L2/L3, L3/L4, L4/L5, L5/S1 in both groups. The parameters measured were :

i. The thickness of LF at L2/L3, L3/L4, L4/L5, L5/S1 in axial view (mm)
ii. Cranial & caudal extension of LF (mm) in mid sagittal plane.
iii. The sub/infralaminar of maximum extension of the LF were identified in mid sagittal plane.
iv. The anterior-posterior of Lf encroachment (mm): lumbar disc herniation (mm) from mid sagittal MRI of lumbar spine were measured in sagittal view. (spinal stenosis group)
v. The thickest LF location in relation to the lamina length from the inferior lamina (spinal stenosis group) were identified.

All the measurements were confirmed with the radiologist and all measurement will be repeated 14 days apart to minimize recall bias.

Measurement of i, ii,iii & v



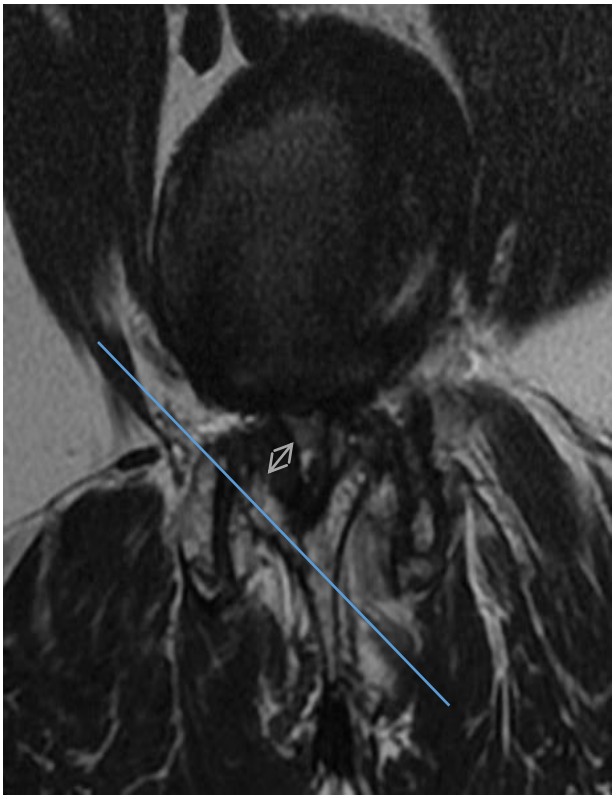


Figure 1 **Figure 2**

Figure 1 : Sagittal view of MRI

On the sagittal T1-weighted image, the slice with maximal thickness of ligamentum flavum was traced using the cursor and gave corresponding axial cut of the lumbar level of interest. Sublaminar/cranial extension was the distance between the lower edge of lamina and the apex of the LF. **Infralamina/caudal extension** was the distance between the lower edge of lamina and the bottom of the LF

Figure 2 :

On the axial T1-weighted image through the facet joint, the LF was clearly observed as a low-signal intensity mass just at the ventral side of the facet joint. A straight line was drawn along the facet joint. The ligamentum flavum thickness were measured.

ANATOMICAL MRI DESCRIPTION

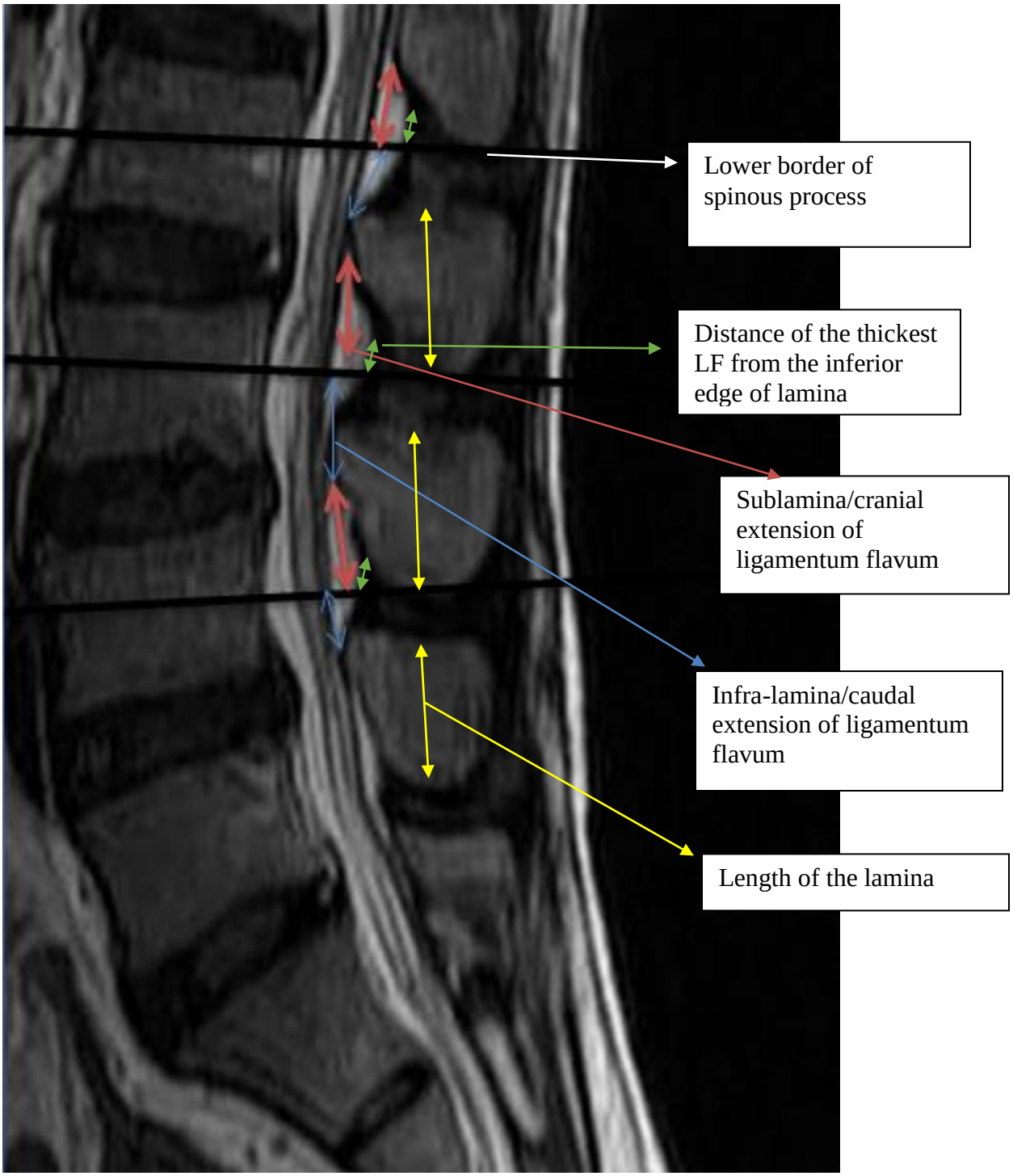


FIGURE 3.

Figure 3 shows the parameters measured in this study